

Space Weather Technical Forecast

Issued on Friday, 29 October 2021 at 14:37 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Large CME expected to arrive at Earth later on Saturday 30th into Sunday 31st. Average G1/G2 storming with a likelihood of G3 at times. Watch issued, possible G3 warning to follow. Low to Moderate Solar Activity continuing.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity was High, with an X1.0 flare at 28/1535UTC (AR2887), M1 at 29/0244UTC, and a couple of C flares following that. AR2887 is a moderately sized complex region in the southern central disc, which appears to be simplifying a little. AR2891 (Dki/Beta-gamma) in the northeast has remained fairly inactive in the last 24 hours, despite its history of M-flaring, though recent coronagraph imagery suggests an increase in magnetic looping and flux. Three other sunspots remain, all weak affairs, making 5 in total on the visible disc. The X-class flare from AR2887 resulted in a large full-halo Earth-directed CME. This feature has been analysed and is currently most likely to arrive at Earth around 30/1600UTC, plus or minus several hours given error bounds.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR at L1 was at background levels, declining from 310 km/s to around 280 km/s. The density has been at or above average levels (7-17ppcc). The strength of the interplanetary magnetic field (IMF), Bt, was weak throughout and below 6nT, and with a mainly positive north-south Bz component. The phi angle was in the negative sector (towards the Sun) throughout. Geomagnetic activity was Quiet throughout, Kp 0-1.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured by GOES-16 has been at S1 minor storm since the X flare yesterday, reaching S1 from 28/1735UTC onwards. There is a slight declining trend but it has been steady for the last 18 hours. 100MeV Protons have also been at active thresholds, reaching 10ppcc at 28/1810UTC, now gradually declining to 1.6ppcc. The High energy electron flux (greater than 2 MeV) was predominantly at background levels with the associated 24-hour electron fluence below the Active (1e8 integrated pfu) threshold, with 3.07e6 integrated pfu recorded at 29/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar Activity is forecast to be Moderate to Low over the next 4 days with a chance of further M-class flares and slight chance (10%) of another X-class flare, primarily from AR2887 or AR2891.

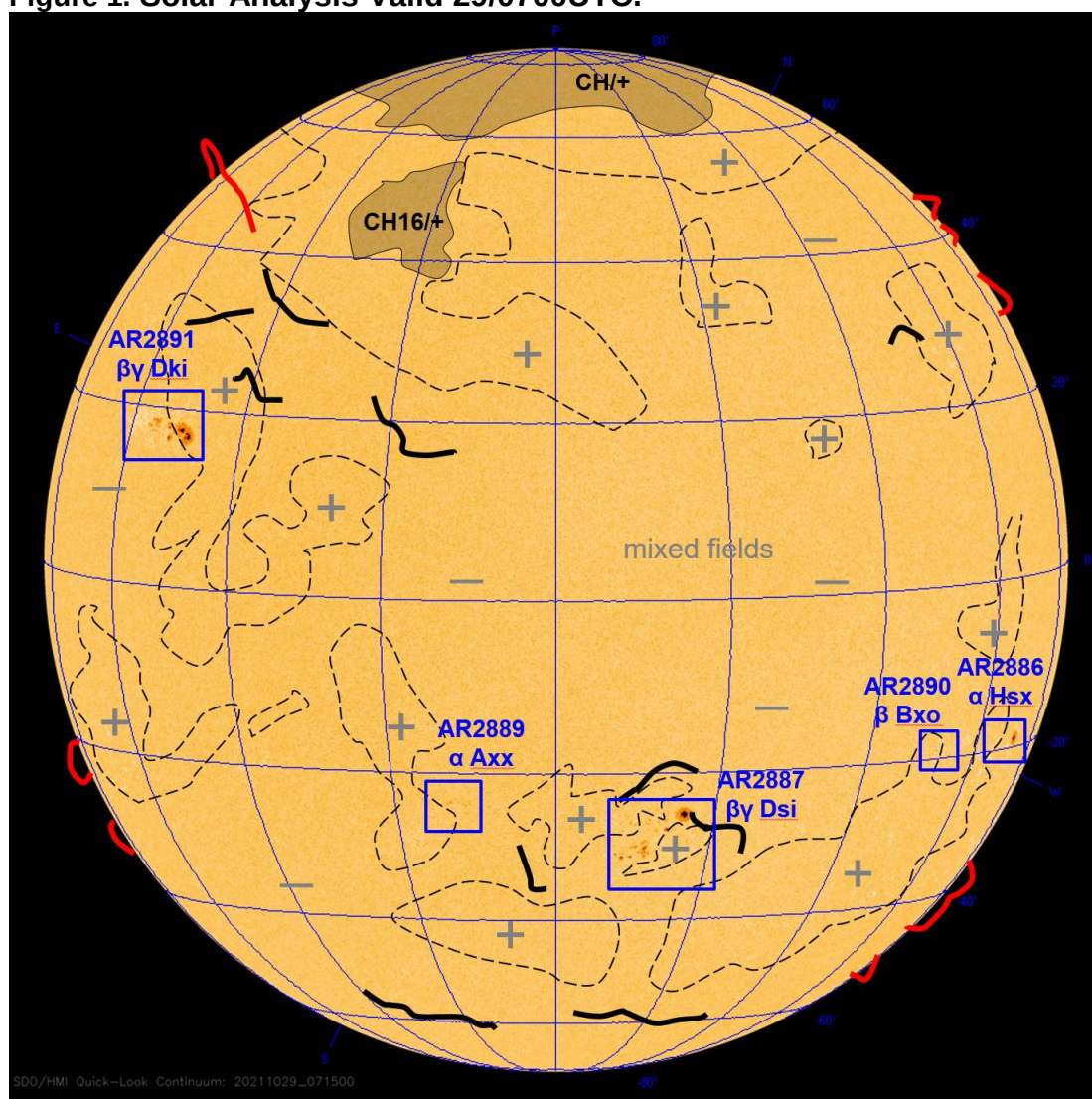
Solar Wind / Geomagnetic Activity: A large CME from an X-class flare eruption on the 28th has been analysed and is forecast to arrive at Earth during the second half of Day 2 (30th), most likely around 1600UTC. Geomagnetic activity is expected to be quiet until then (Kp0-2). During the CME transit, minor to moderate geomagnetic storms (G1/G2 Kp5-6) are expected, with a likelihood of isolated G3/Strong storms (Kp7). Geomagnetic activity is then expected to gradually subside during the latter part of Day 3 into Day 4 (31st October into 1st November) with an

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

eventual return to mainly Unsettled levels, with a chance of Active intervals (Kp2-4).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux will continue at S1/Minor storm level for the second half of Day 1 (29th). In the absence of any further significant flares the high energy proton flux is expected to return to background levels during Day 1, but with a continued slight chance of reaching the S1 level again with any notable flares for from the CME arrival itself on 30th/31st. The high energy electron flux (greater than 2 MeV) is forecast to remain mostly at background levels between Days 1 and 3 (29th-31st), but with a risk of exceeding the Active level (1e3pfu) threshold at times during the latter part of Day 3 into Day 4 (31st into the 1st) as Geomagnetic activity following the expected CME arrival subsides. From a low start, the associated 24 hour fluence is expected to remain largely below the Active (1e8 integrated pfu) level, but with a slight chance of exceeding this threshold on Day 4 (1st November).

Figure 1. Solar Analysis Valid 29/0700UTC.



Key: Filament — , Prominence — , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - γ - δ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

A large full-halo CME was observed leaving the sun in coronagraph imagery following the X-class flare from AR2887 on the 28th at 1535UTC. This feature has been analysed, is Earth-directed and expected to arrive later in the UTC day (around 1600 UTC) on Day 2 (30th).

A small filament eruption that occurred on the 26/2000 UTC has the potential to give glancing effects on passing behind the Earth, most likely late on the Day 2 or early Day 3 (31st), but anything from this is likely to be swept up in the larger CME.

Solar winds are currently at background levels. There are no coronal holes of interest for the forecast period on the visible disc, with no notable fast wind enhancements expected aside from the predicted CME arrival. Geomagnetic activity is forecast to be mainly Quiet for the rest of Day 1 and early Day 2, with a slight chance of isolated Unsettled intervals. From later Day 2 into Day 3, Minor to Moderate Geomagnetic storms (G1/G2) are expected with the CME, with a likelihood of isolated G3/Strong storms (Kp7). Geomagnetic activity is then expected to gradually subside later Day 3 and more especially Day 4 (31st to 1st November) with an eventual return to mainly Unsettled levels, with a chance of Active intervals (Kp2-4).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	1	90	80	40
Strong	G3	No	1	60	60	5
Severe	G4	No	1	10	10	5
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
28/1844	Full	AR2887	Centre disc ~South 20deg	1200km/s	30/1600UTC	G1-G2 avergae with isol G3. Significant shockwave evident ahead of ejecta. Possible strong magnetic cloud following.

Figure 2: Latest ENLIL model takes the CME to L1 by 30th October 1600UTC.

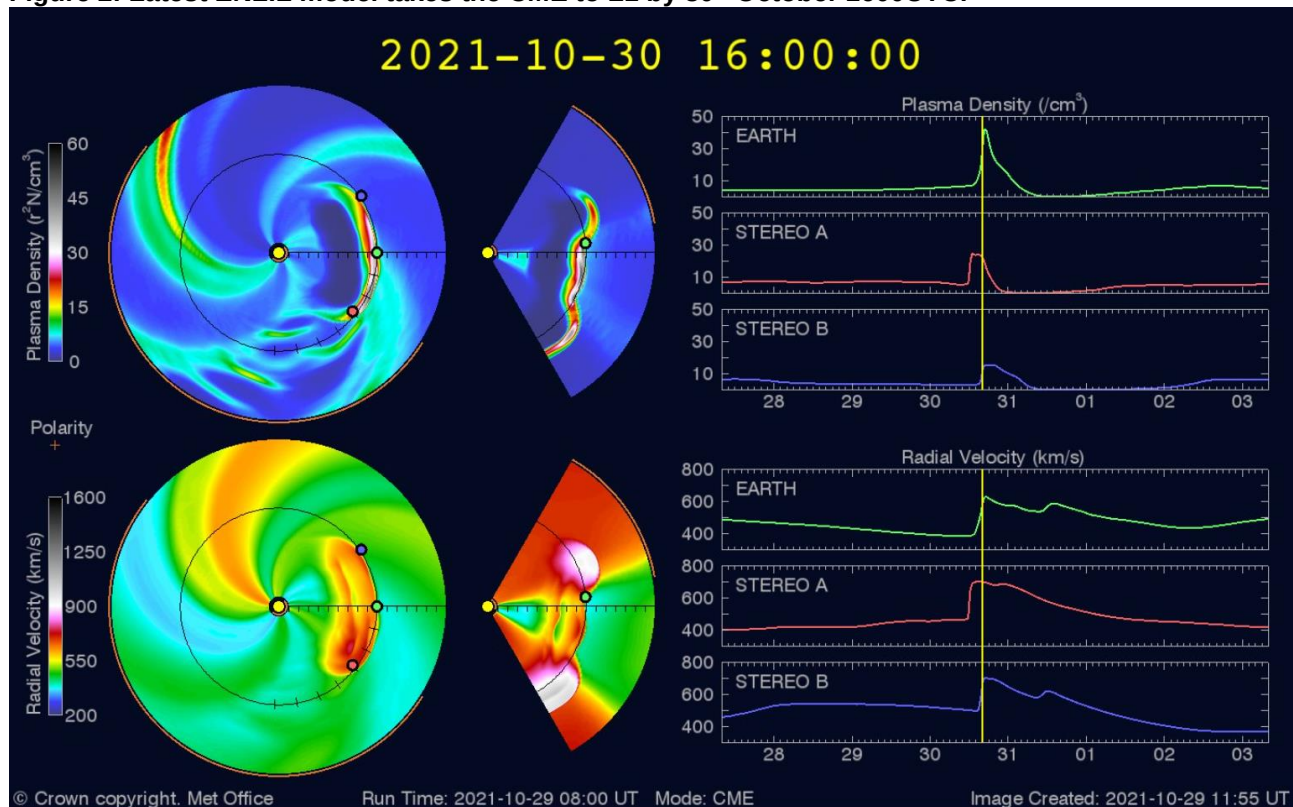
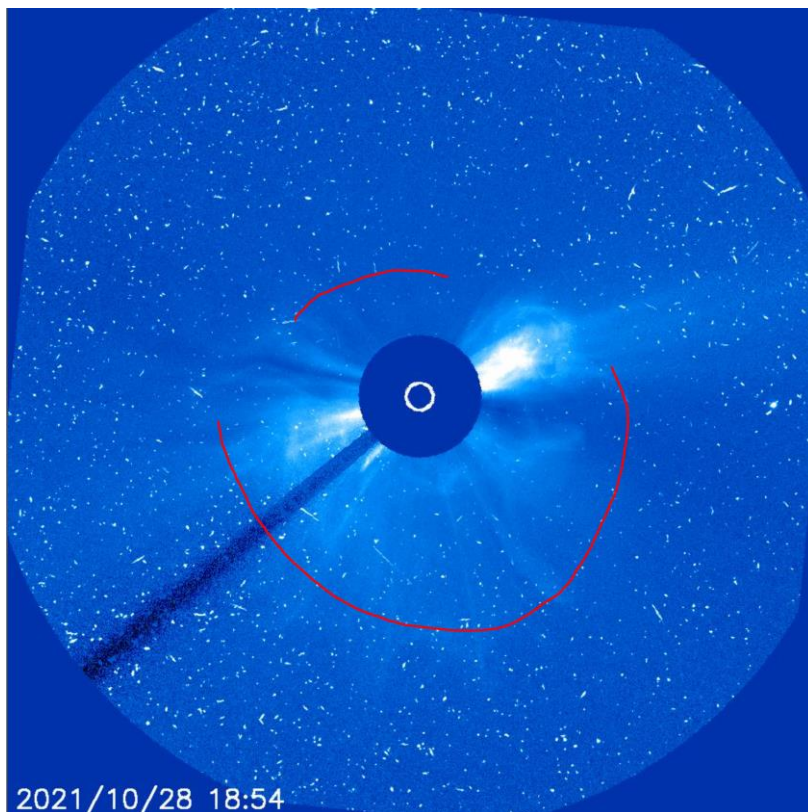


Figure 3: SOHO C3 imagery of the full halo. Note slow bulbous CME in the 2 O'clock position is from a coronal relaxation event earlier in the day (separate non-Earth Directed CME).



Radio Blackouts - X-Ray Flares:

Solar Activity has been High, with two M-flares from AR2887 (Dai/Beta-gamma-delta) in the last 24 hours. AR2891 Dki/Beta-gamma in the northeast has remained fairly inactive in the last 24 hours, despite its history of M-flaring, though recent coronagraph imagery suggests an increase in magnetic looping and flux and holds the potential for significant flares. AR2889 Axx/Alpha in the southeast and AR2890 Bxo/Beta in the southwest have continued to gradually decay, whilst AR2886 Hsx/alpha has persisted as an inactive and mature feature. STEREO-A EUVI 195 imagery suggests there are two or three bright flux regions that are expected to rotate onto the Earth-facing disc in the next four days.

Activity is expected to be at Moderate to Low levels mainly, with a chance of further M-flares and a slight chance of X-class flares, most likely from AR2887 or AR2891.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	40	40
Very Active	R3 to R5 X Class	Yes	10	10	5	5

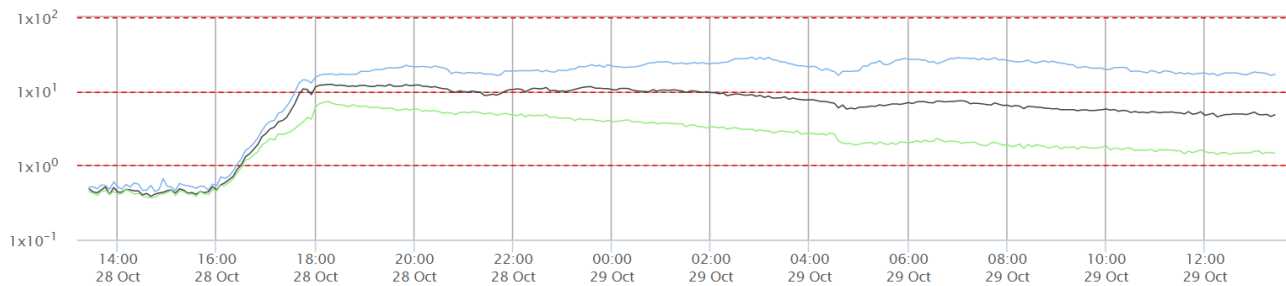
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at S1/Minor storm levels. In the absence of any further significant flares the high energy proton flux is expected to return to background levels during Day 1, but with a continued slight chance of reaching the S1 level again with any notable flares or impacts from the CME itself. The slight increase in probabilities of S1/Minor storms on Day 4 is as AR2887 moves into a more favourable location on the sun.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	Yes	100	30	10	20
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

Figure 4: GOES16 High energy Protons, Blue showing 10MeV, Black showing 50MeV, and Green showing 100MeV. Slow declining trend but interestingly steady on the 10MeV. The S1 storm could therefore last into Saturday morning, and may even enhance a little with the arrival of the CME itself.



High Energy Electrons Event ($\geq 2\text{MeV}$):

The high energy electron flux (greater than 2 MeV) as observed by GOES-16 at GEO is currently at background levels and expected to remain at this or moderate levels for much of the period. The expected arrival of the large CME on the 30th may act to initially suppress the Van Allen radiation belts before possibly injecting electrons into the radiation belts once geomagnetic activity resides a little during Days 3 and 4. This means that an increase in electron flux is possible on Day 3 (31st) and Day 4 (1st November) with some uncertainty. With this comes a chance of reaching the Active fluence threshold ($1\text{e}8$ integrated pfu) on Day 4. REFM is expected to give reasonably good guidance until the 30th.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1\text{e}8$	No	1	1	20	35
Very Active	$\geq 2 \text{ MeV}$ $\geq 1\text{e}9$	No	1	1	1	1

Figure 5: Latest Met Office REFM

